Renewable Energy 134 (2019) 1248–1261

Contents lists available at ScienceDirect

Renewable Energy

journal homepage: www.elsevier.com/locate/renene

Measuring public acceptance of climate-friendly technologies based on creativity and cognitive approaches: Practical guidelines for reforming risky energy policies in Iran

Abdolvahhab Fetanat [a, **], Gholamreza Shafipour [b, *], Seyedeh-Maryam Mohtasebi [a]

[a] Department of Electrical Engineering, Behbahan Branch, Islamic Azad University, Behbahan, Iran
[b] Young Researchers and Elite Club, Behbahan Branch, Islamic Azad University, Behbahan, Iran

ARTICLE INFO

Article history:
Received 10 November 2017
Received in revised form
17 July 2018
Accepted 30 August 2018
Available online 7 September 2018

Keywords:
Fuzzy cognitive map
Gas
Lotus blossom technique
SCAMPER
Public acceptance
Solar water heater

ABSTRACT

In order to mitigate climate change and reduce fossil fuel dependency in Iran, the government of the country has announced its renewable energy policies to increase the use of renewable energies, but the share of the energy generation mix of Iran is very low due to the lack of public acceptance. These challenges continue and can be hard to overcome at all levels. This paper investigates this problem at regional level by measuring public acceptance towards development of climate-friendly technologies in order to provide required feedbacks to policy-makers of the government for ushering changes in their policies already made or in their executing mechanism, possibly deducting future risks such as public opposition from their end and improving the level of acceptance. This study uses a mixed-methods analytical approach for quantitatively taking that level, including creativity techniques and fuzzy cognitive maps (FCMs). FCMs could directly map out policy-makers' cognitions on the problem. This study provides the mathematical formulation of the problem with its conceptual interpretation to import policy-makers' knowledge into FCMs when the knowledge is gained explicitly with creativity techniques. The authors focused on a case of Solar Water Heater adoption in the city of Behbahan in Khuzestan Province.

© 2018 Elsevier Ltd. All rights reserved.

1. Introduction

Since Iran has very rich fossil energy resources, 99% of energy production in Iran comes from oil and gas. Based on this issue, little attention has been paid so far to evaluate renewable energy production. The largest part of country's income is from oil and gas. It put extra pressure on its natural resources. Thus, the sustainability study should be of interest to policy-makers. Iran is located in the world's Sun Belt and has an annual average of sun radiation about 20–30 MJ/m^2 that is even higher in the central regions (Fig. 1) [1].

Research studies revealed that the amount of actual solar radiation hours in the country exceeds 2800 h per year [2–6]. Furthermore, the sunny hours of the four seasons are 700 h during spring, 1050 h during summer, 830 h during autumn and 500 h during winter. Although Iran is a country with sunny weather throughout the year, due to the following reasons, there were limited applications to use solar energy. One reason has been the fuel price for producing electricity and the other is the oil export, since eighty percent of Iran's income is based on oil and gas exports [7–9]. Given the solar potential of the country, it is necessary to install large numbers of solar energy technologies such as solar water heater (SWH) for maintaining the present level of oil and gas exports and also for increasing the security of Iran energy supply.

When making policies on climate-friendly technologies that can have extensive effects, policy-makers use their understanding of risks such as public opposition that are associated with their choices to guide their decisions. The knowledge of what people expects from these technologies can help the identification of effective actions aimed at giving appropriate answers to the questions of people that are often opposing the technologies simply because they do not have adequate information about them and their impacts.

For example, in one research study organized by Sovacool [10] various stakeholders were interviewed in USA about renewable

* Corresponding author.
** Corresponding author.
E-mail addresses: av-fetanat@behiau.ac.ir (A. Fetanat), pp_shafipour@yahoo.com (G. Shafipour), maryammohtasebi@yahoo.com (S.-M. Mohtasebi).

https://doi.org/10.1016/j.renene.2018.08.107
0960-1481/© 2018 Elsevier Ltd. All rights reserved.

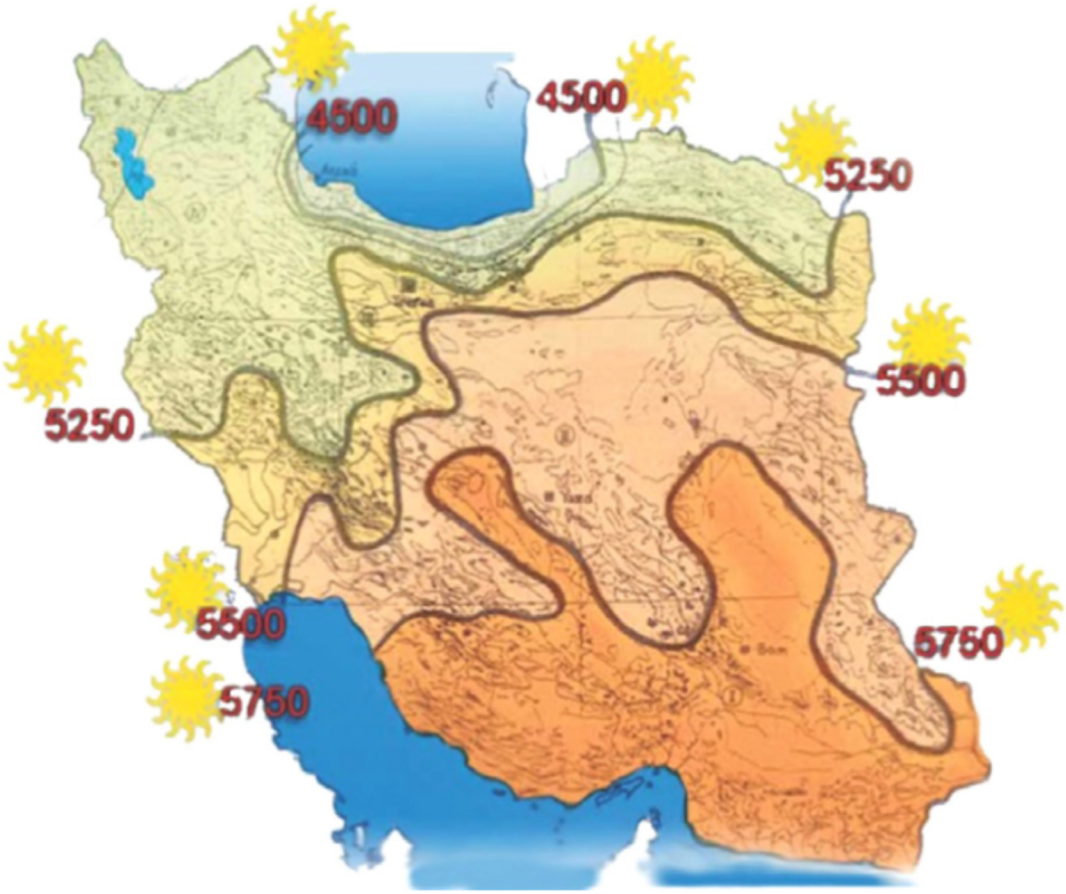

Fig. 1. Potential of solar energy in Iran.

power systems' contribution to national electricity generation. Sovacool presented a comprehensive network of impediments from technological, social, political, regulatory, and cultural aspects which he termed as socio-technical. His article revealed that social or cultural barriers are critical, such as utility operators reject renewable resources because they are trained to think only with regard to big, conventional power plants. Also, Sovacool [11] evaluated the cultural impediments to renewable technologies by conducting interviews at institutions. Sovacool found that the apparent disconnect between how electricity is produced and how it is socially perceived perpetuates public apathy and misinformation; also that extremely held values related to consumption, abundance, trust, control and freedom shape American attitudes toward energy. He noted that psychologists and economists have observed that people hold a strong preference for the status quo. Once they are familiar with a particular energy product, it attains a higher value. This conflict with the view that people will invest in changing their lifestyle if this would maximize self-interest. Farhar and Coburn [12] interviewed a large number of single-family homeowners in Colorado about the installation of PV system on their roof-top. In regard to favorability of PV systems, the score was 7.5 (out of 10). In terms of familiarity with PV systems, the score was 3.2 (out of 10). Mukwada et al. [13] investigated social factors which decisively affect the acceptance of SWH project in Bluegumbosh, Africa. In one research study conducted by Chen et al. [14], a large number of Chinese university students were interviewed about how social and psychological factors such as environmental attitudes, perceived behavioral control, subjective and descriptive norms, and renewable energy knowledge affect individuals' intention to use SWHs and alternative fuel vehicles and support renewable energy policies. Yuan et al. [15] in their study use a quantitative approach to investigate the social acceptance of SWH and the solar PV, from end users' perspective in Shandong province, China. The study presented that there is a substantial high level of social acceptance and public awareness of SWH. But, solar PV has not gained a high level of social acceptance or public awareness. Zhai and Williams [16] examined the role of consumer acceptance and model its effect on the adoption of residential PV. The authors presented a fuzzy logic inference model to relate consumer perception variables to their purchasing probability. Arkesteijn and Oerlemans [17] examined factors having an effect on the likelihood of adoption and nonadoption of green electricity by households. To achieve this particular aim, the authors provided a theoretical framework rooted in cognitive science complemented with variables derived from economic theory. Bhandari and Jana [18] carried out a survey to evaluate the impact of household characteristics on the preference for electrical energy from Solar PV systems. The survey revealed that household characteristics (e.g., monthly household income, household size, occupational status of household head, number of room and type of house) significantly influence household's decision for installing these systems.

Despite increasing efforts in studying the problem of public acceptance of climate-friendly technologies and feedbacks between the public and policy-makers, understanding these dynamics and future risks remains challenging. This to some extent relates to:

a. unknown future behavior of the public
b. non-technical forces that shape the adoption of the technologies by residents, particularly at the regional level
c. nonlinear effects caused by the public and policy-makers
d. and uncertainty linked to causalities existing amongst them

When these feedbacks are highly uncertain and to large extent difficult to control, it may be more correct to consider possible future scenarios (i.e. alternatives that capture uncertainties about the future of the problem, and provide insights into factors influencing the problem, implications of current policies, and different options for effective actions) that include main uncertainties rather than to focus on a precise estimate of a single outcome.

Past adoption patterns for clean energy technologies in Iran have shown that it is difficult to develop relevant plausible scenarios to the acceptance problem by thinking in a conventional mode. Logical thinking takes the government of the country existing knowledge and uses rules of inference to produce new knowledge. However, because logical thinking progresses in a series of stages, each one dependent on the previous, this new knowledge is only an extension of what the government knows already, rather than being truly new. Because of the inadequacies of logical thinking, it has only a limited role to play in helping policy-makers of the government to be creative.

For these reasons, the authors of this study decided to combine creativity techniques such as Lotus Blossom and SCAMPER with Fuzzy Cognitive Maps (FCMs) to provide the mathematical formulation of the acceptance problem in Iran with conceptual interpretation in order to develop relevant plausible scenarios, assess options to deal with future risks and measure public acceptance of climate-friendly technologies in the country.

These creativity techniques can help policy-makers of the government to generate ideas, connect them from different domains of their knowledge, and explore random combinations between them in the same area for differently looking at the problem in order to develop the skills needed to be an effective interpreter in the processes of making renewable energy policies.

FCM aims to encapsulate qualitative knowledge from policy-makers to construct a simple dynamics model of the problem. By focusing on causality, it can help facilitate policy-makers' discussions to identify how the public and policy-makers interact in a wider complex social system and understand how the influences of these interacting actors can vary during different stages of the policy process. The authors combine the advantages of these creativity techniques with FCMs in such a manner that the fuzzy part of a cognitive map is able to address uncertainties, which occurs in human perception of the problem.

In order to the development of climate-friendly technologies in the country, the local setting should receive some guideline in order to use effectively its own resources through a series of strategies. To achieve the stated goal, the key research question for this research study is:

What are the important factors that are needed for the successful deployment of climate-friendly technologies at the local level and how do they interact?

In order to answer the above-mentioned question and achieve the aim of this research, the case study of Solar Water Heater (SWH) adoption in the city of Behbahan in Khuzestan province is discussed.

The rest of the paper is organized as follows: In Section 2, the research methodology is presented. It covers the reasons for selecting the study area, data sources, data analysis and a brief summary of the expectations from the mixed method adopted. In the third Section, the proposed method is explained in details for the study area. Finally, the conclusions and policy implications are described in Section 4.

2. Research methodology

As stated in Section 1, the purpose of this study is to create a better understanding of the interplay between different policies for climate-friendly technologies development (e.g. SWHs) and the dynamics of the social attitude towards these technologies at the regional level in the social context of Iran. It focuses on measuring the social influences of local adaptations to the adoption of SWHs. There is more information about the research methodology of the study below:

- ***The selection of the study area*:** The research justification stems from an interest to solve the acceptance problem of SWHs in relation to a particular location in Iran. The selected area i.e. the city of Behbahan in Khuzestan province was chosen because the province has rich reserves of solar energy but currently the share of solar energy sources in the energy generation mix of the province is very low and the main share of energy demand in it is covered by fossil fuels such as gas. In fact, the purpose of this selection is to contribute to the understanding on how the city of Behbahan can develop strategies for solving the acceptance problem of SWH development in order to reduce the dependency of the region on gas. Over a 10-month period beginning in March 2017, the case study was conducted.
- ***Participants:*** Ten experts from the regional government, SWH producer companies, non-governmental organizations, local communities and academia participated in this study for gaining a better understanding of solar water heater use in the city, including physical and technical objects associated with the adoption of SWH (such as installation, operation, maintenance) and determining factors affecting the adoption project. The total number of the experts was selected heuristically, i.e., the decision to stop adding the experts was taken when nothing new was being learnt from them. The experts were carefully chosen on the basis of their closeness to the subject.
- ***Data sources:*** Data sources mainly covered the government publications, academic literature, Internet web pages, technical documents, annual reports of the SWH producer companies and in-person interviews. Also, valuable insight was gained from the analysis of research studies conducted by the government of the country on renewable energy projects. It helped the authors to recognize the main challenges and barriers in the process of SWH adoption, as well as main factors in the field that influence this process. In-person interviews constituted one of the most valuable sources of information. This type of interview allows the authors to clarify any misunderstandings of the subject and guide the dialogue while at the same time allowing interviewees to answer in their own words with limited influences from the authors. The questions of interviews (e.g. What are specific barriers during the planning, implementation and maintenance stages of the project of SWH adoption?, Are there any unexpected outcomes (either positive or negative) from the this adoption? and so on) were designed to stimulate the dialogue about the motivations for the SWH adoption. All the interviews were conducted in Persian and for the purpose of this paper were translated into English by the authors. To gain an increasingly deep understanding of each expert's viewpoints and of causal relationships between the relevant factors, the authors systematically analyzed the information gathered from these interviews through iterative re-reading of them. Then, they sent the notes of interview to each of the experts within four days of the interview for any corrections. Once the interview notes were reviewed by each of the experts, the notes were

analyzed to identify factors affecting the adoption project. The interviews were about 40–50 min in length.

- ***Mixed method:*** As mentioned in Section 1, to achieve the objective of this study, the authors employed a mixed method including Lotus Blossom, SCAMPER and Fuzzy Cognitive Maps. The method provides required feedbacks to policy-makers for ushering changes in their policies already made or in their executing mechanism, possibly deducting future risks such as the opposition of local residents from their end and improving the acceptance level.
- ***Procedure:*** In order to achieve the aim of this research, a six-step framework based on the above-mentioned methods is proposed (see Fig. 2). Fig. 2 shows how these steps are interrelated. These steps consider that policy-makers decide what factors influencing SWHs development in the city of Behbahan should explored (Step 1 is in use in this case). When it comes to how causalities existing amongst these factors are going to be assessed in relation to the subject, Step 2 plays its role. In deciding which the policy impacts will be occurred, it is Step 3 that is being used. When saying about why they occurred is at issue, Step 4 is in use. Different forms of understanding of the subject may come into play and if they require the policy-makers to evaluate the current impacts of their policies, the use of Step 5 is suitable. Finally, when the aspects of the adoption project are presented in order to raise local residents' knowledge about the problem, Step 6 is in use.

2.1. The lotus blossom creative technique

This technique is used to discover the basic causes of problems. To reach this goal, it tracks whole systems of interacting elements in resemblance of peeling of the petals of the lotus blossom [19]. The Lotus Blossom approach concentrates on the power of brainstorming on areas of interest. It does so through the use of a visual representation of ideas and is similar to a mind-map like relevance tree, but is more structured. This brainstorm approach begins with its structure. It is a simple technique and the relevant process can be repeated with each petal, opening further into more petals. In the Lotus Blossom, ideas develop gradually, from a simple to a more complicated form. Because the components of the technique are dynamic, it finds the key relationships and how they interact. The process starts by defining a central idea and expanding it into sub-ideas (Petals), each with separate entry points. In Lotus Blossom, the petals around the core of the blossom are figuratively peeled back one at a time, revealing a key idea. This approach is pursued in ever-widening circles until the idea is thoroughly explored. The group of ideas and surrounding ideas, which are developed in one way or another, provide a variety of different alternative possibilities.

2.2. Fuzzy cognitive maps

2.2.1. Fuzzy set theory

Because of incomplete, unavailable and non-measurable information, much of the decision-making in the real world could not

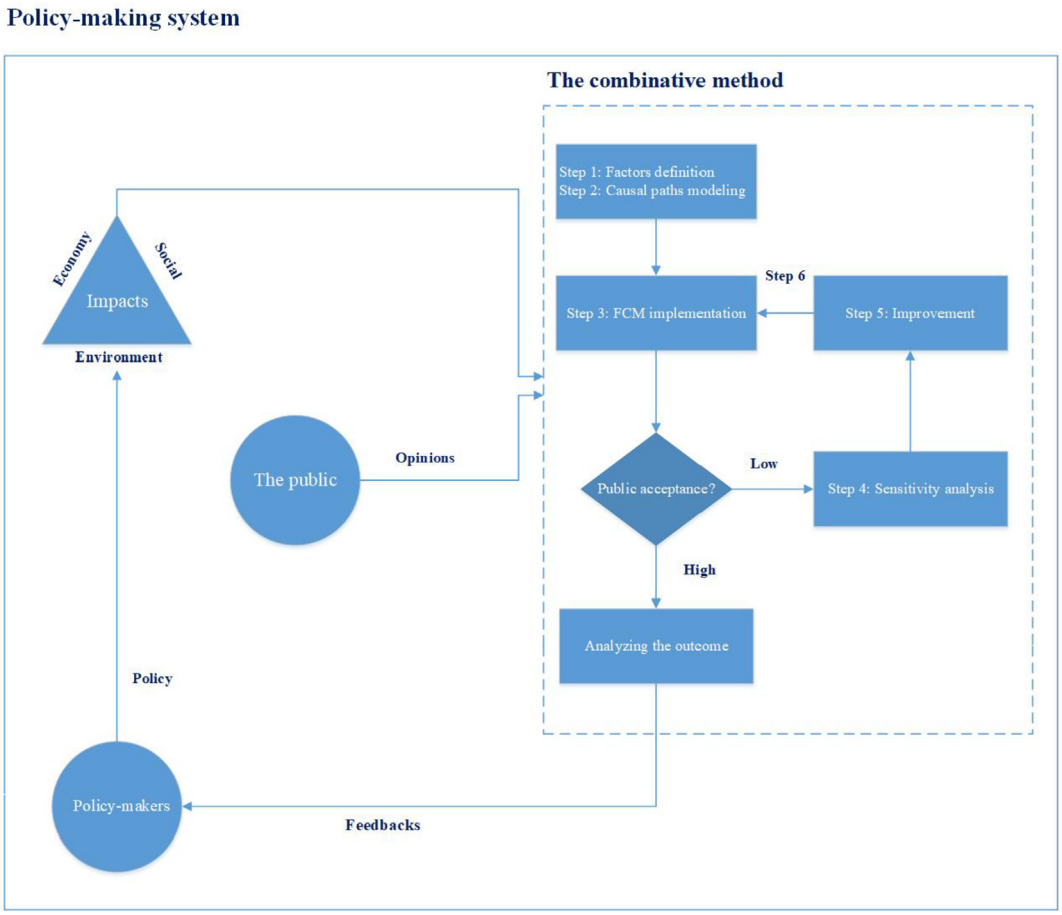

Fig. 2. The conceptual model of the study.

perform undoubtedly. Fuzzy set theory as a mathematical method was first developed to solve these problems. Decision-makers tend to decide depending on their past experiences, knowledge. Thus, their estimations are often a function of vagueness and linguistic terms. To combine the experiences, opinions and ideas of decision-makers, it is better to convert the linguistic estimation to fuzzy number. For this reason, the need for fuzzy logic in decision-making problems in the real world is introduced. Some essential definitions of fuzzy logic and linguistic terms are briefly presented as follows [20]:

Definition 1. A fuzzy set $\tilde{A}$ is a subset of a universe of discourse X, which is characterized by a membership function (MF) $\mu_{\tilde{A}}(x)$ describing a mapping $\mu_{\tilde{A}}$: $x \rightarrow [0, 1]$. The function value of $\mu_{\tilde{A}}(x)$ is called the membership value, which represents the degree of truth that x is an element of fuzzy set $\tilde{A}$. It is supposed that $\mu_{\tilde{A}}(x) \varepsilon [0, 1]$, where $\mu_{\tilde{A}}(x) = 0$ reveals that x belongs completely to $\tilde{A}$, while points out that x does not belong to the fuzzy set $\tilde{A}$.

Definition 2. A fuzzy set $\tilde{A}$ of the universe of discourse X is convex if and only if

$$\mu\tilde{A}(x_1 + (1-\lambda)x_2) \geq \min\left(\mu\tilde{A}(x_1),\ \mu\tilde{A}(x_2)\right) \quad \forall x \in [x_1, x_2], \quad \lambda \in [0, 1] \tag{1}$$

Definition 3. A fuzzy set $\tilde{A}$ of the universe of discourse X is normal if

$$\max \mu\tilde{A}(x) = 1. \tag{2}$$

Definition 4. A fuzzy number $\tilde{M}$ is a fuzzy subset in the universe of discourse X, which is both convex and normal.

Definition 5. The α-cut of the fuzzy set $\tilde{A}$ of the universe of discourse X is defined as

$$\left\{\tilde{A}\alpha = x \in X \middle| \mu\tilde{A}(x) \geq \alpha\right\},\ where\ \alpha \cdot \in [0, 1] \tag{3}$$

Definition 6. A triangular fuzzy number $\tilde{M}$ can be described as a triplet (l, m, u), and the MF $\mu_{\tilde{M}}(x)$ is described as

$$\mu\tilde{M}(x) = \begin{cases} 0 & x < l \\ (x-l)/(m-l) & l \leq x \leq m \\ (u-x)/(u-m) & m \leq x \leq u \\ 0 & x > u \end{cases}$$

where l, m, and u are real numbers and $l \leq m \leq u$. See Fig. 3.

Definition 7. Linguistic variables are used as variables whose values are not numbers but linguistic terms.

The linguistic-variable approach is generally employed by the decision-makers to express their assessments, which is very useful in dealing with uncertain, incomplete and unspecific situations in traditional quantitative expressions. Linguistic values can be represented with fuzzy numbers. In particular, the triangular fuzzy numbers are usually used. The MFs are the building blocks of fuzzy set theory, i.e., fuzziness in a fuzzy set are determined by its MF. Consequently, the shapes of MFs are important for a particular problem since they effect on a fuzzy inference system. They may have different shapes like triangular, trapezoidal, Gaussian, etc. The only condition an MF must really satisfy is that it must vary between 0 and 1. The simplest MFs are formed using straight lines. These straight line MFs have the advantage of simplicity. Of these, the simplest is the triangular membership function.

2.2.2. FCM background

An FCM describes the behavior of a system in terms of concepts; each concept is an input, an output, a rule or an intermediate state [21,22].

$$C_i, \quad i = 1, \ldots, N$$

Where N is the total number of concepts in the FCM. The value A of each concept is fuzzified in the space [0, 1].

$$A_i \in [0,\ 1], \quad i = 1, \ldots, N$$

Concepts are interconnected with arcs that vary with different weights (W_{ij}).

These weights represent the relationship among concepts. Human knowledge and experiences are used to decide on the values of the weights. The weights can express positive, negative or neutral causality and take values in the space [-1, 1].

$$W_{ij} \in [-1,\ 1], \quad i = 1, \ldots, N \ \ and\ j = 1, \ldots, N$$

For example, a simple FCM with five concepts is presented in Fig. 4 [22].

The FCM weights can be represented by a matrix.

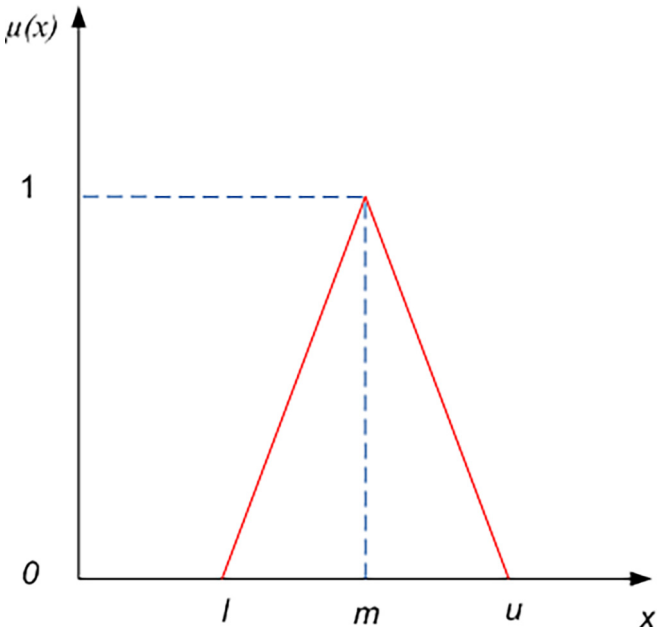

Fig. 3. A triangular fuzzy number $\tilde{M}$.

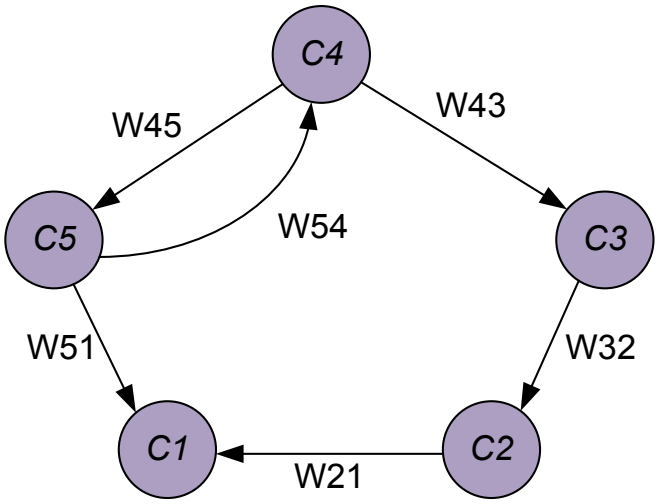

Fig. 4. A fuzzy cognitive map.

$$W = \begin{bmatrix} W_{11} & W_{12} & W_{13} & W_{14} & W_{15} \\ W_{21} & W_{22} & W_{23} & W_{24} & W_{25} \\ W_{31} & W_{32} & W_{33} & W_{34} & W_{35} \\ W_{41} & W_{42} & W_{43} & W_{44} & W_{45} \\ W_{51} & W_{52} & W_{53} & W_{54} & W_{55} \end{bmatrix}$$

The matrix for the FCM can be simplified by using zeros where there is no relation between the concepts. The matrix of FCM presented in Fig. 4 is as follows:

$$W = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ W_{21} & 0 & 0 & 0 & 0 \\ 0 & W_{32} & 0 & 0 & 0 \\ 0 & 0 & W_{43} & 0 & W_{45} \\ W_{51} & 0 & 0 & W_{54} & 0 \end{bmatrix}$$

The influence between the concepts of the FCM is described by Eq. (4) [23]. This equation converges after a number of iterations. This number is affected by the number of concepts and their interconnections.

$$A_i(k+1) = f\left(A_i(k) + \sum_{\substack{j=1 \\ j \neq i}}^{n} W_{ij} A_i(k)\right) \tag{4}$$

Where k is the number of the iterations.

Function f in Eq. (4) is the activation function of the FCM. Many functions have been proposed to distinguish different situations. These include the sigmoid function, the hyperbolic tangent function, the step function and the threshold linear function. The sigmoid function has been compared to other activation functions of FCM and has been proved to be a useful tool for decisional processes make available to decision-makers [24], also in clear production management application [25], the sigmoid function that is used is presented in Eq. (5).

$$f(x) = \frac{1}{1 + e^{-cx}} \tag{5}$$

When the steepness parameter (C) is equal to 1, it approximates a linear function [24,26,27].

2.3. SCAMPER technique

SCAMPER is an acronym for seven stimuli that suggest some addition to, or modification of a problem that already exists [19]. The technique is used to help experts analyze and consider all aspect of the problem and find an effective solution.

The seven stimuli that SCAMPER stands for are as follows:

1. S (Substitute): Remove some part of the problem under discussion and replace it with something else.
2. C (Combine): Combine two or more parts of the problem to create a different process and consider ways that such a combination might move the process toward a solution.
3. A (Adapt): Change some part of the problem so that the problem where it did not before now.
4. M (Magnify): Magnify parts of the problem. This way may give experts new insights about what components are most important.
5. P (Put to other uses): Modify the intention of the subject and put it to other uses. Generally, an idea only becomes important when differently used than first supposed.
6. E (Eliminate): Remove ideas from the subject that are not valuable.
7. R (Rearrange (or Reverse)): Modify the order of parts of the process or any other chain of components involved.

3. Illustration: measuring public acceptance of climate-friendly technologies – the example of SWH adoption

3.1. Study area

In urban areas in the southern parts of Iran, the most popular technologies for the supply of hot water are central gas burning boilers that are placed in cellars of buildings. But, the situation in the northern parts of Iran is completely different as gas pipelines are absent in these areas. It is common for local residents of this region to heat their domestic water by electricity, which is an expensive and limited resource.

In recent years, electricity and gas increased in price. Consequently, this issue has increased the demand for SWHs. The use of SWHs allows:

- electricity to be freed for greater local economic activities,
- opportunities for entrepreneurship,
- more local skilled employment,
- less carbon emissions from gas consumption.

In Southern Iran such as Khuzestan province, there are barely any space heating systems as they are not needed during the year because of climatic conditions. In these regions, solar potential is excellent (see Fig. 1). Thus, solar energy can be used for heating of incoming water so that gas and electricity use can be minimized.

Social acceptance of climate-friendly technologies has been investigated in very few cases in Iran. To explore the social attitude towards these technologies, we opted for a case study of SWH adoption in the city of Behbahan, Khuzestan province.

Khuzestan is the major oil-producing region of Iran, and as such is one of the gas-rich regions in the country. It is situated in the southwest of the country (see Figs. 1 and 5).

In general, the climate of this province is very hot and occasionally humid, particularly in the south, while winters are much more cold and dry. Summertime temperatures routinely exceed 111° Fahrenheit and in the winter it can drop below freezing, with occasional snowfall. Khuzestan is possibly one of the hottest places on earth with maximum temperature in summer soaring up to 131°

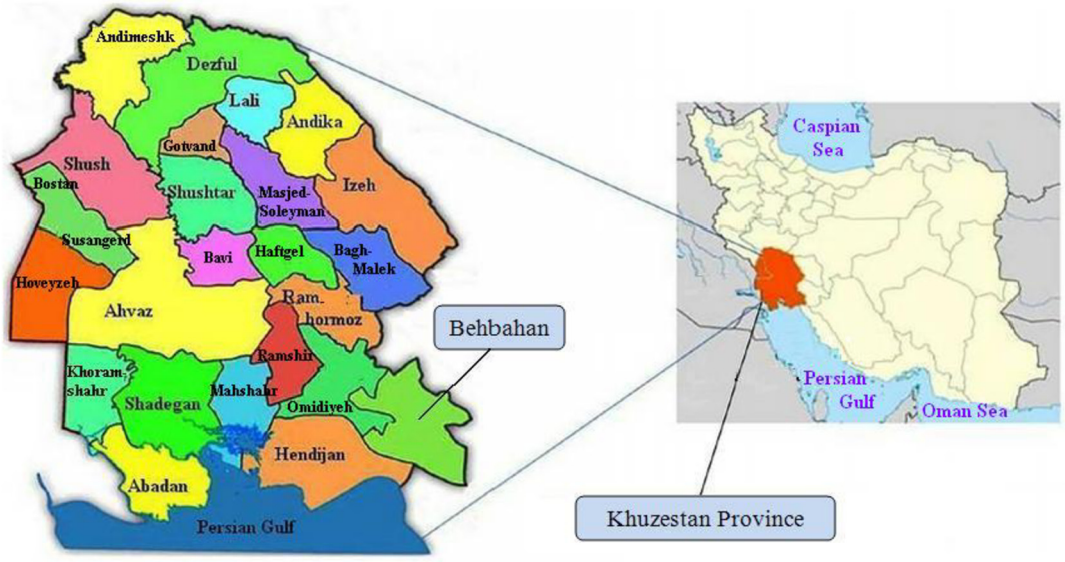

Fig. 5. Study area.

Fahrenheit air temperature with temperatures coming close to 140° Fahrenheit at times.

3.2. The mathematical formulation of the problem with conceptual interpretation

The combinative method is created using a six-step framework developed by the authors (see Fig. 2).

Step 1: Factors definition.

Interviews with ten experts were carried to understand key factors influencing the adoption in the city.

Then, the relevant factors are worded as concepts that can be caused and can exert causation, and then divided into 9 main concepts in order to make them easier to analyze. The 9 concepts are the key contextual factors of the problem.

Step 2: Causal paths modeling.

In order to model causal paths among the factors, the lotus blossom technique as an ideation technique is used as follows:

1. Draw up a lotus blossom diagram (see Fig. 6) made up of a square in the center of the diagram and eight squares (petals) around it;

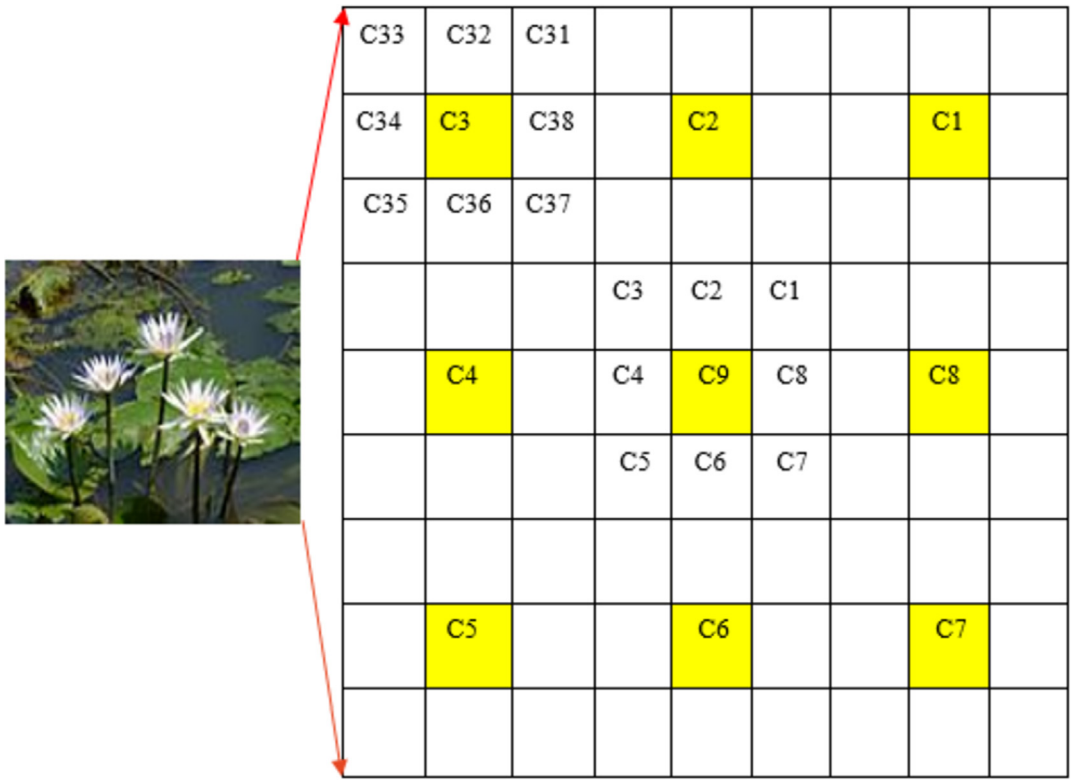

Fig. 6. The Lotus Blossom diagram of the problem.

2. Write the central idea under discussion in the center of the diagram (C_9);
3. Look for eight key determinants of the public acceptance (C_1 to C_8). Then write them in the flower petals. These are sub-ideas which are to be explored later. This original diagram becomes the original Lotus Blossom diagram. Each of the sub-ideas is seeds for more Lotus Blossoms.
4. Each sub-idea seed becomes the central idea for a new Lotus Blossom diagram. This process is repeated for each of the original sub-ideas.
5. Once all the Lotus Blossom diagrams have been created, they can be used for additional discussions.

The technique allows policy-makers to generate diagrams in a graphic form that allows them to see unmistakably the interrelationships between the factors that are.

- dependent on specific features of the adoption problem,
- dependent on specific features of local residents,
- dependent on processes for policy-making.

Managerial implications of the Lotus Blossom technique are as follows:

- The technique can be used to identify more or less suitable perspectives of the problem for the deployment of SWH.
- It can be used to alert policy-makers to different determinants of the problem that need to be taken into account.
- Policy-makers can use the technique to develop effectively an awareness of the suitability of different policies for the successful deployment of SWH.

Step 3: FCM implementation.

This step can be controversial since the outcome of this step is an indication that reveals the acceptance level of the deployment of SWH.

The stages implemented in this study to construct FCMs are modeled in the following figure (see Fig. 7). For example, ten experts as focus group are represented by the ten arrows in the flow diagram.

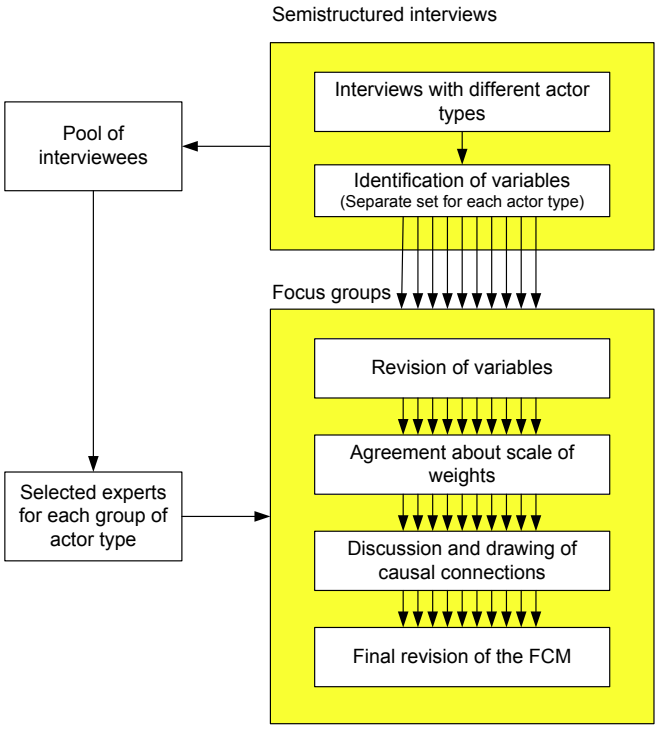
Semistructured interviews
Interviews with different actor types
Identification of variables
(Separate set for each actor type)
Pool of interviewees
Focus groups
Revision of variables
Agreement about scale of weights
Discussion and drawing of causal connections
Final revision of the FCM
Selected experts for each group of actor type

Fig. 7. The stages of FCM implementation [27].

The step uses FCM as a way of obtaining uncertain knowledge of the local people about the possible factors affecting the adoption of SWH. FCM captures uncertainty in causal relationships. The fuzziness future of FCM allows hazy degrees of causality between hazy causal concepts.

The FCM of the study is constructed according to the following stages:

Stage 1: Definition of concepts.

Two types of concepts are going to be used in the proposed FCM; input and output concepts. The output concept will be the overall evaluation of the public acceptance (i.e. C_9). The input concepts are C_1 to C_8 and their relevant sub-concepts resented in Step 1 (see Table 1).

Stage 2: determination of the value of inputs.

The eleven linguistic variables as shown in Fig. 8 are used for determining the value of each input (see Table 2). The corresponding triangular fuzzy numbers of these linguistic variables is shown in Table 3.

According to Table 3 and Fig. 8, a triangular fuzzy number for each of the inputs is calculated. Then, these numbers are transformed in numerical values using the Yager defuzzification method

Table 1
Factors pertaining to the problem of SWH adoption.

ID	Factor
C_1	Gas
C_{11}	Gas energy cost
C_{12}	The amount of gas consumption
C_{13}	awareness of the public about finitude of fossil fuels
C_2	Culture
C_{21}	Public information about this field
C_{22}	Awareness of the public through local medias
C_{23}	Awareness of the public through national medias
C_{24}	Awareness of comparative advantages of solar water heater
C_{25}	Assurance
C_3	Water
C_{31}	Water pressure
C_{32}	Salt in the water (water quality)
C_{33}	Water temperature at early morning hours by solar water heater
C_{34}	Water temperature in the cold months
C_4	Environment
C_{41}	Solid waste
C_{42}	Use of fossil fuels
C_{43}	co_2 emission
C_{44}	Air and water Pollution
C_5	Cost
C_{51}	The average income for a majority of people
C_{52}	Cost of sales of solar water heater
C_{53}	Installation cost
C_{54}	Credits in this field
C_{55}	Maintenance cost
C_6	Social Terms
C_{61}	People's life style
C_{62}	People's attitudes toward the technology and modernity
C_{63}	The public's behaviors
C_{64}	Access to credit in order to progress
C_{65}	Social participations
C_{66}	Social studies in this field
C_7	Public opposition and fear
C_{71}	Fear of a loss of quality of life
C_{72}	Fear of exposure to innovation and its risk
C_{73}	Knowledge of the local people
C_{74}	Age
C_{75}	Trust in the energy transition
C_{76}	Reliability of the equipment
C_{77}	Ability to relocate or change
C_8	Business
C_{81}	Correlation with the change of technology in this field
C_{82}	Number of producer companies in the field
C_{83}	Access to institutions, sales and after sales service and skilled repairman.
C_9	Public acceptance

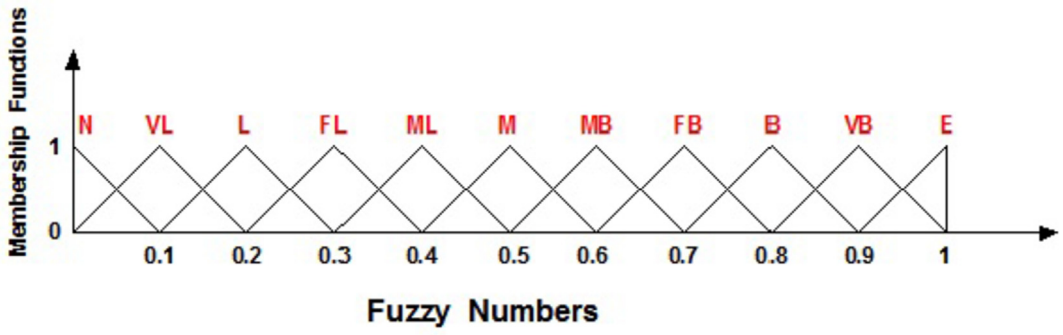

Fig. 8. Membership function for the defuzzification of Concepts. Stage 3: Defuzzification of the FCM inputs.

Table 2
FCM inputs.

FCM Input	Value	Abbreviation
C_1	By calculation	
C_{11}	Low	L
C_{12}	A lot of gas	B
C_{13}	Lack of knowledge	L
C_2	By calculation	
C_{21}	The relative Lack of public information	ML
C_{22}	Inadequate information	L
C_{23}	Very inadequate information	VL
C_{24}	In long term especially for environment is not good	L
C_{25}	Very inadequate Assurance	VL
C_3	By calculation	
C_{31}	Medium	M
C_{32}	Big	B
C_{33}	Fairly low water temperature	FL
C_{34}	Fairly low water temperature	FL
C_4	By calculation	
C_{41}	Fairly Big	FB
C_{42}	Very Big	VB
C_{43}	Fairly Big	FB
C_{44}	More or less Big	MB
C_5	By calculation	
C_{51}	Fairly low	FL
C_{52}	Fairly Big	FB
C_{53}	Low	L
C_{54}	Very low	VL
C_{55}	Fairly Big	FB
C_6	By calculation	
C_{61}	Medium	M
C_{62}	Medium	M
C_{63}	Fairly Big	FB
C_{64}	Very low	VL
C_{65}	Fairly low	FL
C_{66}	Very low	VL
C_7	By calculation	
C_{71}	More or less Big	MB
C_{72}	More or less Big	MB
C_{73}	Medium	M
C_{74}	Medium	M
C_{75}	More or less low	ML
C_{76}	More or less low	ML
C_{77}	Medium	M
C_8	By calculation	
C_{81}	Very low	VL
C_{82}	Low	L
C_{83}	Very low	VL

(See Eq. (6)). Table 4 shows this matter.

$$M_{i,j} = \int_0^1 \frac{1}{2}\left(\left(\tilde{M}_{i,j}\right)_l^{\alpha} + \left(\tilde{M}_{i,j}\right)_{\alpha}^{u}\right)\, d\alpha = \frac{l_{i,j} + 2m_{i,j} + u_{i,j}}{4} \qquad (6)$$

Stage 4: Definition of the FCM weights.

For each pair of concepts C_i and C_j presented in Fig. 6, If-Then rule is used for assigning linguistic weights in order to evaluate concepts. The If-Then rule is described as below:

IF C_i change THEN causes value of concept C_j change THUS the influence of concept C_i on concept C_j is W_{ij}.

The weights characterize the interconnections and describe the degree of causality between two concepts. The five linguistic variables as shown in Fig. 9 are used for weighting. The related triangular fuzzy numbers of linguistic variables for weights are shown in Table 5.

Table 3
Linguistic variables for inputs.

Linguistic term	Abbreviation	Triangular fuzzy numbers
None	N	(0,0,0.1)
Very low	VL	(0,0.1,0.2)
Low	L	(0.1,0.2,0.3)
Fairly low	FL	(0.2,0.3,0.4)
More or less low	ML	(0.3,0.4,0.5)
Medium	M	(0.4,0.5,0.6)
More or less Big	MB	(0.5,0.6,0.7)
Fairly Big	FB	(0.6,0.7,0.8)
Big	B	(0.7,0.8,0.9)
Very Big	VB	(0.8,0.9,1)
Excellent	E	(0.9,1,1)

Using Table 5 and the membership function presented in Fig. 9, the linguistic values are transformed in triangular fuzzy numbers. The aggregated fuzzy weights can be calculated as:

$$l_{i,j} = \sqrt[N]{\Pi_{k=1}^{N} B_{ijk}},\ m_{i,j} = \sqrt[N]{\Pi_{k=1}^{N} B_{ijk}},\ u_{i,j} = \sqrt[N]{\Pi_{k=1}^{N} B_{ijk}} \qquad (7)$$

where B_{ijk} is the degree of causality between concept i and concept j (W_{ij}) determined by kth expert, N = 10 is the number of experts and $\tilde{M} = (l_{i,j},\ m_{i,j},\ u_{i,j})$ is the triangular fuzzy number. These values are then defuzzified in the space [0,1]. The weights are presented in Table 6.

Stage 5: Production of the FCM.

In this stage, the lotus blossom diagram of the study (output from Step 2) combines with the FCM weights to produce the FCM. Fig. 10 presents the FCM of the study.

Stage 6: formation of the W matrix.

Using the information provided in Table 5, the W matrix can be formed. By using this matrix with Eqs. (4) and (5) and assuming C parameter in Eq. (5) equal to 1, the output i.e. the strength of impact of the concepts C_1 to C_8 on the concept C_9 can be calculated. The greater the strength of the impact is, the greater the level of the public acceptance is.

Stage 7: Defuzzification of the output.

As stated, the output concept will have a value in the space [0,1].

Table 4
Defuzzification of the FCM inputs.

Input	Value	Defuzzified numbers
C_1		
C_{11}	L	0.2
C_{12}	B	0.8
C_{13}	L	0.2
C_2		
C_{21}	ML	0.4
C_{22}	L	0.2
C_{23}	VL	0.1
C_{24}	L	0.2
C_{25}	VL	0.1
C_3		
C_{31}	M	0.5
C_{32}	B	0.8
C_{33}	FL	0.3
C_{34}	FL	0.3
C_4		
C_{41}	FB	0.7
C_{42}	VB	0.9
C_{43}	FB	0.7
C_{44}	MB	0.6
C_5		
C_{51}	FL	0.3
C_{52}	FB	0.7
C_{53}	L	0.2
C_{54}	VL	0.1
C_{55}	FB	0.7
C_6		
C_{61}	M	0.5
C_{62}	M	0.5
C_{63}	FB	0.7
C_{64}	VL	0.1
C_{65}	FL	0.3
C_{66}	VL	0.1
C_7		
C_{71}	MB	0.6
C_{72}	MB	0.6
C_{73}	M	0.5
C_{74}	M	0.5
C_{75}	ML	0.4
C_{76}	ML	0.4
C_{77}	M	0.5
C_8		
C_{81}	VL	0.1
C_{82}	L	0.2
C_{83}	VL	0.1

This output is defuzzified qualitatively (Very low, Low, Medium, Big and Very Big) so as to express how SWH is perceived by local residents. The defuzzification membership function is presented in

Table 5
Linguistic variables for weights.

Linguistic term	Abbreviation	Triangular fuzzy numbers
Very low influence	VL	(0,0,0.25)
Low influence	L	(0,0.25,0.5)
Medium influence	M	(0.25,0.5,0.75)
Big influence	B	(0.5,0.75,1)
Very Big influence	VB	(0.75,1,1)

Fig. 9. For this study C_9 is equal to 0.12 i.e. the level of the acceptance is Very low. This finding means, in the Behbahan City, there is still considerable optimism about gas heater waters and also, levels of uncertainty about SWH applications among the local residents are high and relates to a significant lack of knowledge on the adoption and related factors. It suggests the need for more educational activities in order to increase the public awareness of SWH and to reduce citizen doubts. To achieve this purpose, we use SCAMPER method in Step 5.

Step 4: Sensitivity analysis.

The output from the FCM indicated that local residents did not support the location of SWHs in their areas. Therefore, a sensitivity analysis on the FCM of the study is needed to assess the effects of varying the input concepts in the problem.

The sensitivity analysis shows that $C_{13}, C_{24}, C_{25}, C_{32}, C_{33}, C_{34}, C_{52}, C_{53}, C_{54}, C_{55}, C_{81}, C_{82}, C_{83}$ are the underlying concepts that exert the greatest influence on the SWH adoption.

Step 5: Improvement.

As low acceptance level of the SWH adoption, can seriously frustrate the development of the technology, it is essential to reconsider the concepts that selected in Step 4 in order to raise policy-makers' knowledge about the problem. The aim of this step is to improve the public acceptance. Based on SCAMPER, this step involves an ability to come up with new and different viewpoints on the value of these concepts. It involves breaking down and restructuring policy-makers' knowledge about the concepts in order to gain new insights into its nature. It may also result in efforts to improve the public acceptance. These make it a natural tool for creativity.

Based on the seven stimuli, the technique uses a set of idea-spurring questions to suggest some modification of the value of the concepts. Consider, for instance, the following questions for the problem:

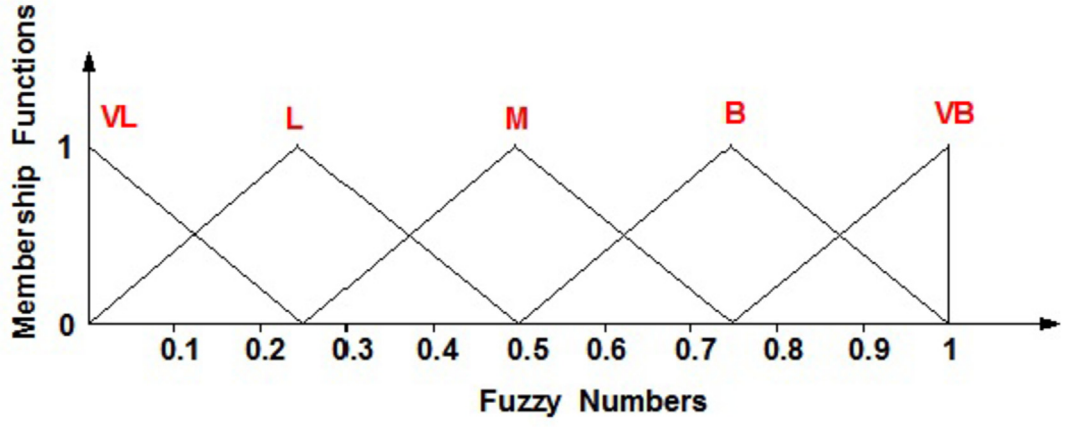

Fig. 9. Membership function for the defuzzification of weights.

Table 6
FCM weights.

Variable	Experts										Defuzzified value
	1	2	3	4	5	6	7	8	9	10	
$W_{11\ 1}$	VB	B	B	VB	VB	VB	B	VB	VB	VB	0.87
$W_{12\ 1}$	VB	VB	VB	B	VB	VB	B	VB	VB	VB	0.88
$W_{13\ 1}$	B	B	VB	VB	B	VB	VB	B	VB	VB	0.86
$W_{1\ 9}$	B	VB	B	B	VB	B	VB	B	B	VB	0.84-
$W_{21\ 2}$	VB	MB	B	FB	B	VB	MB	VB	FB	B	0.77-
$W_{22\ 2}$	MB	B	MB	FB	VB	FB	B	VB	B	MB	0.74-
$W_{23\ 2}$	L	FL	ML	ML	M	MB	FB	M	ML	L	0.42-
$W_{24\ 2}$	M	MB	MB	B	B	B	MB	FB	MB	M	0.65-
$W_{25\ 2}$	MB	M	B	B	MB	VB	FB	VB	B	B	0.74-
$W_{2\ 9}$	B	MB	B	B	FB	M	VB	B	FB	M	0.71-
$W_{31\ 3}$	FB	FB	B	B	VB	FB	B	MB	FB	MB	0.73
$W_{32\ 3}$	B	B	VB	MB	FB	MB	FB	B	FB	VB	0.75-
$W_{33\ 3}$	M	MB	M	B	MB	FB	B	FB	B	B	0.68-
$W_{34\ 3}$	B	MB	MB	M	FB	MB	B	MB	FB	B	0.67-
$W_{3\ 9}$	M	MB	M	M	MB	B	ML	L	B	FB	0.56
$W_{41\ 4}$	MB	B	VB	VB	B	FB	B	VB	B	FB	0.79
$W_{42\ 4}$	B	VB	B	B	B	VB	B	MB	B	FB	0.79
$W_{43\ 4}$	VB	VB	B	B	VB	VB	B	VB	VB	B	0.86
$W_{44\ 4}$	B	B	VB	VB	B	VB	VB	B	VB	VB	0.86
$W_{4\ 9}$	B	MB	VB	B	MB	FB	B	VB	MB	FB	0.74
$W_{51\ 5}$	B	VB	VB	B	VB	VB	B	VB	FB	VB	0.85-
$W_{52\ 5}$	B	B	B	VB	FB	VB	B	VB	FB	B	0.81-
$W_{53\ 5}$	MB	M	FB	MB	M	FB	MB	M	B	FB	0.62-
$W_{54\ 5}$	B	MB	FB	FB	FB	MB	B	FB	B	MB	0.7-
$W_{55\ 5}$	B	VB	B	VB	B	B	B	VB	FB	B	0.82-
$W_{5\ 9}$	B	VB	B	B	FB	VB	B	B	VB	FB	0.81-
$W_{61\ 6}$	B	M	L	M	B	VB	MB	VB	B	M	0.65
$W_{62\ 6}$	M	MB	ML	M	B	MB	MB	ML	MB	B	0.58
$W_{63\ 6}$	M	MB	M	MB	FB	B	B	MB	FB	B	0.66
$W_{64\ 6}$	B	FB	M	MB	B	VB	MB	B	B	FB	0.72-
$W_{65\ 6}$	B	M	MB	B	B	MB	MB	B	M	B	0.68-
$W_{66\ 6}$	B	VB	B	MB	FB	ML	M	MB	FB	B	0.68-
$W_{6\ 9}$	B	MB	MB	FB	B	MB	FB	FB	B	M	0.68-
$W_{71\ 7}$	MB	FB	B	VB	B	M	L	M	FB	B	0.65-
$W_{72\ 7}$	L	B	VB	B	FB	M	B	B	FB	B	0.7-
$W_{73\ 7}$	B	B	VB	M	L	MB	FB	M	B	VB	0.67
$W_{74\ 7}$	B	M	L	VB	FL	FB	B	VB	B	B	0.67
$W_{75\ 7}$	B	VB	B	VB	VB	B	B	VB	B	VB	0.85-
$W_{76\ 7}$	B	VB	B	FB	B	MB	M	B	FB	VB	0.75-
$W_{77\ 7}$	B	M	VB	L	B	VB	B	VB	B	FB	0.73-
$W_{7\ 9}$	B	M	B	FB	MB	B	VB	FB	B	FB	0.73-
$W_{81\ 8}$	FB	B	L	B	B	M	MB	FB	B	VB	0.68-
$W_{82\ 8}$	B	M	B	FB	B	VB	B	FB	B	M	0.73-
$W_{83\ 8}$	M	B	VB	B	FB	B	VB	FB	MB	B	0.75-
$W_{8\ 9}$	FB	MB	FB	B	B	B	FB	FB	B	FB	0.73-

Where L:Low; FL:Fairly low; ML: More or less low; M: Medium; MB: More or less Big; FB: Fairly Big; B: Big; VB: Very Big

- **S**: Are there any concepts that could be replaced to improve the level of acceptance?
- **C**: What would happen if we combine the existing materials of the SWH with others? Is it going to be something better, or worse? Would it affect the opinions and attitudes of the population towards SWH?
- **A**: Are there any technologies that could be used in SWH?
- **M**: How could we change the shape or color of SWH? What could we emphasize or highlight to create more value?
- **P**: Can this product be used in other places in other forms? Who else could use it in addition to the primary target?
- **E**: What concepts of the problem can be eliminated? How can we simplify the problem?
- **R**: Can the cause concepts and the effect concepts be swapped?

By answering these questions, the values of the concepts that selected in Step 4 are modified as follows:

$$C_{13} : 0.2(\mathrm{L}) \xrightarrow{\text{increase}} 0.7(\mathrm{FB})$$

$$C_{24} : 0.2(\mathrm{L}) \xrightarrow{\text{increase}} 0.6(\mathrm{MB})$$

$$C_{25} : 0.1(\mathrm{VL}) \xrightarrow{\text{increase}} 0.8(\mathrm{B})$$

$$C_{32} : 0.8(\mathrm{B}) \xrightarrow{\text{decrease}} 0.3(\mathrm{FL})$$

$$C_{33} : 0.3(\mathrm{FL}) \xrightarrow{\text{increase}} 0.7(\mathrm{FB})$$

$$C_{34} : 0.3(\mathrm{FL}) \xrightarrow{\text{increase}} 0.7(\mathrm{FB})$$

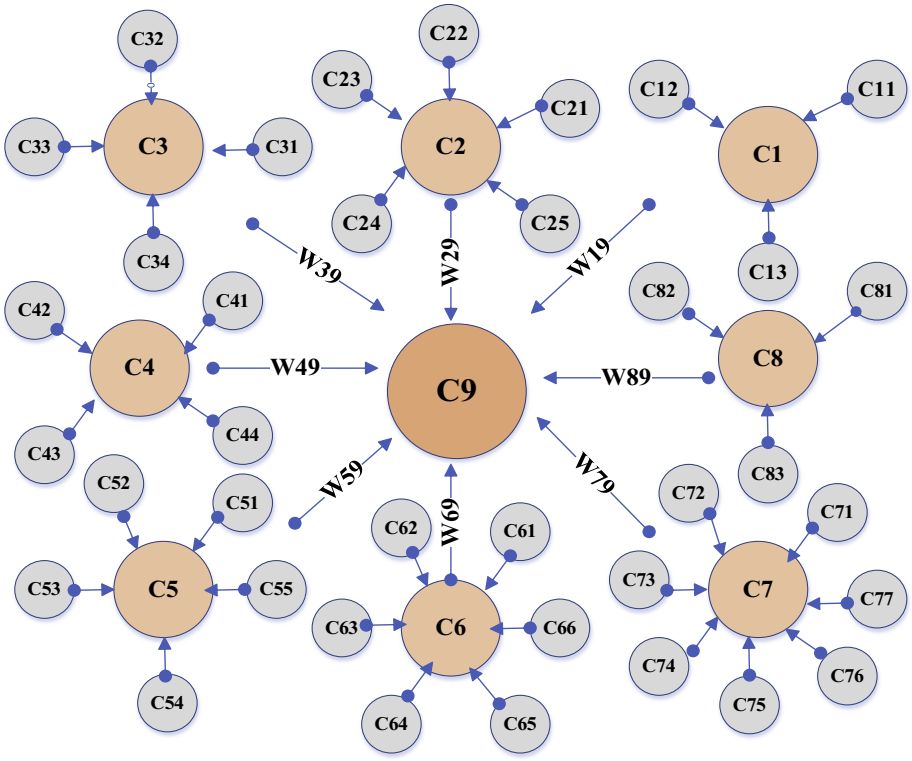

Fig. 10. The FCM of the study.

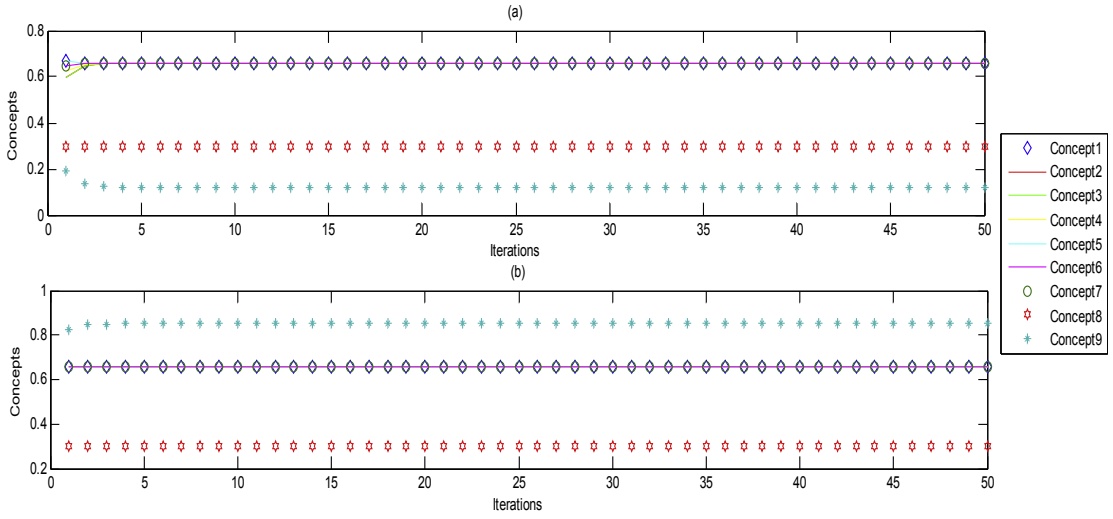

Fig. 11. The final results: (a) before SCAMPER implementation and (b) after SCAMPER implementation.

$C_{52}: 0.7(\mathrm{FB}) \xrightarrow{\text{decrease}} 0.5(\mathrm{M})$

$C_{53}: 0.2(\mathrm{L}) \xrightarrow{\text{increase}} 0.7(\mathrm{FB})$

$C_{54}: 0.1(\mathrm{VL}) \xrightarrow{\text{increase}} 0.6(\mathrm{MB})$

$C_{55}: 0.7(\mathrm{FB}) \xrightarrow{\text{decrease}} 0.5(\mathrm{M})$

$C_{81}: 0.1(\mathrm{VL}) \xrightarrow{\text{increase}} 0.6(\mathrm{MB})$

$C_{82}: 0.2(\mathrm{L}) \xrightarrow{\text{increase}} 0.6(\mathrm{MB})$

$C_{83}: 0.1(\mathrm{VL}) \xrightarrow{\text{increase}} 0.6(\mathrm{MB})$

Step 6: Go back to the FCM mode, reconstruct the weight matrix of FCM and calculate new output.

New knowledge of policy-makers about the concepts i.e. the modified values of the concepts that produced in Step 5 are

transferred to Step 3. Based on these new values, the previous output is improved as follows:

$$C_9 : 0.12(\mathrm{VL}) \xrightarrow{\text{increase}} 0.85(\mathrm{VB})$$

The new output indicates that majority of the residents showed interest of supporting the location of SWH project in their areas. Fig. 11 shows this issue.

The iteration process not only raises concepts validity but also helps improve understanding causality among interconnected concepts that gradually become more effective in order to increase the level of public acceptance.

4. Conclusions and policy implications

If the aim of a transition to clean energy generation sources is to mitigate climate changes caused by energy consumption patterns of households, it is necessary to study individual's perceptions of climate-friendly technologies. This means that any policy intervention in changing the patterns should consider cognitive dimensions in the policy process. This problem will vary considerably by geographic locations. In fact, a wide variety of contextual factors at regional level, such as culture (e.g. traditions, beliefs, historical experiences of previous energy transitions, trust in the transition), climatic conditions (e.g. availability and perception of natural resources), socio-economic and infrastructural factors (e.g. business opportunities, energy prices, interest in regional economic development), political and policy issues (e.g. the distribution of power at a region, stability of local current energy policies) determine whether or not local residents of a region engage into the transition. Based on various locations, new contexts create new public acceptance problems for the deployment of these technologies, but they also give rise to new ideas for solving the problem. This matter is particularly important for local level of governance. Even though development of energy transition can happen at the national level, its implementation requires understanding of social factors specifically at the local level, which can be drivers of the transition.

Although some studies in Iran have looked at economic and technical feasibility of deployment of renewable energies, there has been little discussion of public acceptance of climate-friendly technologies specially at local levels. Therefore, the contribution of this study is in its in-depth research of solving a new acceptance problem in relation to a particular location in Iran using a new idea. For this reason, the authors focused on a case study of Solar Water Heater (SWH) adoption in the city of Behbahan, Khuzestan province. As mentioned before, this province is one of the gas-rich regions in the country. Although this province has rich reserves of renewable energies such as solar but currently the share of renewable energy sources in the energy generation mix of the province is very low and the main share of energy demand in it is covered by natural gas. Our surveys gave two reasons for this matter. In the one hand, the current national economic favorability of natural gas, have led the province to increase rapidly their dependence on it. On the other hand, the use of climate-friendly technologies to some extent forces local residents to change their living conditions. They tend to resist these changes in their region, out of a personal fear for a loss of quality of their life. In fact, local residents do not trust these technologies because they do not know them versus gas water heater, which they do know.

If the consumption of natural gas continues to grow, the government of Iran will need to invest in expensive new infrastructures. These investments may lock the government into a high-carbon future. And, as the public pressure to address negative impacts of climate change grows, much of this expensive infrastructure will have to be abandoned.

Compared to other fossil fuels, natural gas can produce reduced air and water pollutants emanating from its power plants, but the current policy in the province is a risky bet on the region's clean energy future.

Recognizing these challenges, the government of Iran settled various types of energy policies with the direction of transition from natural gas to renewable energies such as solar at this province.

This research paper revolves round one key question. It is to understand factors which affect intension of local residents of the region and future decision-makers to use SWHs. Based on this understanding, the paper develops recommendations to policy-making process about how these factors can be addressed and can become drivers for deployment of these technologies in the city of Behbahan.

According to our findings, $C_{13}, C_{24}, C_{25}, C_{32}, C_{33}, C_{34}, C_{52}, C_{53}, C_{54}, C_{55}, C_{81}, C_{82}, C_{83}$ are the underlying factors (concepts) that exert the greatest influence on the SWH adoption.

The acceptance of SWH in the region is not a one-way process in which local residents either accept or reject the adoption project. Rather it is a socially constructed outcome of a process in which residents' views and other features of the technology become mutually aligned, resulting in the SWH adoption project. The authors have operationalized the acceptance of the SWH adoption as the extent to which arrangement is achieved among the expectations of the local residents.

As mentioned before, the acceptance problem is a dynamic process rather than a static feature of the SWH adoption because their contextual factors are not static. The local residents are an important part of these factors, and their involvement in the adoption project is one of the ways in which the factors influence the successfulness of the SWH adoption project.

Thus, in our study, the public acceptance can range from dynamic support (i.e. very big influence of the public on the SWH adoption (See Table 5)) to dynamic resistance (i.e. very low influence of the public on the SWH adoption) and it can evolve as the residents interact with SWHs.

The result of FCM implementation shows that in the Behbahan City there is still considerable optimism about gas energy and its technologies such as gas water heater. And also, levels of uncertainty about the application of SWH among the residents are still low and relates to their significant lack of knowledge on the subject. It reveals that becoming too reliant on natural gas (i.e. intensifying the current energy policy of the province in the future) poses numerous complex risks such as dynamic resistance to renewable energies and their technologies such as SWHs.

FCMs attempt to identify whether the policy impacts occurred, but are limited in saying much about why they occurred. To overcome this issue, the study uses SCAMPER method because it can add rich details to the problem in order to raise local residents' knowledge about the problem and permit an effective analysis of the causes of policy outcomes.

After SCAMPER implementation, the result shows that the coordination of the various interests of the local residents related to the adoption project should be based on and accompanied by the strategy of knowledge improvement action. These results can provide conceptual and mathematical clarity on the acceptance problem in order to not only the policy-makers can evaluate the current impact of their policies, but expect the future impact of their policies more easily.

Acknowledgement

The authors acknowledge financial support from Islamic Azad University grant in Behbahan branch.

References

[1] G. Najafi, B. Ghobadian, R. Mamat, T. Yusaf, W.H. Azmi, Solar energy in Iran: current state and outlook, Renew. Sustain. Energy Rev. 49 (2015) 931–942.
[2] S.M. Besarati, R. Vasquez Padilla, D.Y. Goswami, E. Stefanakos, The potential of harnessing solar radiation in Iran: generating solar maps and viability study of PV power plants, Renew. Energy 53 (2013) 193–199.
[3] H. Dastkhan, M.S. Owlia, What are the right policies for electricity supply in Middle East? A regional dynamic integrated electricity model for the province of Yazd in Iran,, Renew. Sustain. Energy Rev. 33 (2014) 254–267.
[4] H. Khorasanizadeh, K. Mohammadi, A. Mostafaeipour, Establishing a diffuse solar radiation model for determining the optimum tilt angle of solar surfaces in Tabass, Iran, Energy Convers. Manag. 78 (2014) 805–814.
[5] A. Aslani, Marja Naaranojaa, Bahnam Zakerib, The prime criteria for private sector participation in renewable energy investment in the Middle East (case study: Iran), Renew. Sustain. Energy Rev. 16 (2012) 1977–1987.
[6] A. Hajiseyed Mirzahosseini, T. Taheri, Environmental, technical and financial feasibility study of solar power plants by RET Screen, according to the targeting of energy subsidies in Iran, Renew. Sustain. Energy Rev. 16 (2012) 2806–2811.
[7] M. Vafaeipour, S. Hashemkhani Zolfani, M.H. Morshed Varzandeh, A. Derakhti, M. Keshavarz Eshkalag, Assessment of regions priority for implementation of solar projects in Iran: new application of a hybrid multi-criteria decision making approach, Energy Convers. Manag. 86 (2014) 653–663.
[8] H. Valizadeh Haghi, M. Tavakoli Bina, M.A. Golkar, S.M. Moghaddas-Tafreshi, Using copulas for analysis of large data sets in renewable distributed generation: PV and wind power integration in Iran, Renew. Energy 35 (2010) 1991–2000.
[9] M. Mohammadnejad, M. Ghazvini, T.M.I. Mahlia, A. Andriyana, A review on energy scenario and sustainable energy in Iran, Renew. Sustain. Energy Rev. 15 (2011) 4652–4658.
[10] B.K. Sovacool, Rejecting renewables: the socio-technical impediments to renewable electricity in the United States, Energy Pol. 37 (11) (2009) 4500–4513.
[11] B.K. Sovacool, The cultural barriers to renewable energy and energy efficiency in the United States, Technol. Soc. 31 (2009) 365–373.
[12] B. Farhar, T. Coburn, A Market Assessment of Residential Grid-tied PV System in Colorado, U.S. National Renewable Energy Laboratory, Boulder, Colorado, 2000.
[13] Geoffrey Mukwada, Wisemen Chingombe, Phillip Taru, Why social acceptance in south African solar water heater projects should shape national energy policy: the case of bluegumbosch,, Mediterr. J. Soc. Sci. 5 (No 16) (2014) 635–646.
[14] Chien-fei Chen, Xiaojing Xu, Scott Frey, Who wants solar water heaters and alternative fuel vehicles? Assessing social–psychological predictors of adoption intention and policy support in China, Energy Res. Soc. Sci. 15 (2016) 1–11.
[15] X. Yuan, J. Zuo, C. Ma, Social acceptance of solar energy technologies in China—end users' perspective, Energy Pol. 39 (3) (2011) 1031–1036.
[16] Pei Zhai, Eric D. Williams, Analyzing consumer acceptance of photovoltaics (PV) using fuzzy logic model, Renew. Energy 41 (2012) 350–357.
[17] K. Arkesteijn, L. Oerlemans, The early adoption of green power by Dutch households: an empirical exploration of factors influencing the early adoption of green electricity for domestic purposes, Energy Pol. 33 (2005) 183–196.
[18] A.K. Bhandari, C. Jana, A comparative evaluation of household preferences for solar photovoltaic standalone and mini-grid system: an empirical study in a costal village of Indian Sundarban, Renew. Energy 35 (2010) 2835–2838.
[19] R. Histrich, M. Peters, Entrepreneurship, fifth ed., McGraw-Hill, 2002.
[20] E. Khorasaninejad, A. Fetanat, H. Hajabdollahi, Prime mover selection in thermal power plant integrated with organic Rankine cycle for waste heat recovery using a novel multi criteria decision making approach, Appl. Therm. Eng. 102 (2016) 1262–1279.
[21] E.I. Papageorgiou, K.E. Parsopoulos, C.S. Stylios, P.P. Groumpos, M.N. Vrahatis, Fuzzy cognitive maps learning using particle swarm optimization, J. Intell. Inf. Syst. 25 (2005) 95–121.
[22] G. Kyriakarakos, K. Patlitzianas, M. Damasiotis, D. Papastefanakis, A fuzzy cognitive maps decision support system for renewables local planning, Renew. Sustain. Energy Rev. 39 (2014) 209–222.
[23] B. Kosko, Fuzzy Engineering, Prentice Hall, Upper Saddle River, NJ, USA, 1996.
[24] S. Bueno, J.L. Salmeron, Benchmarking main activation functions in fuzzy cognitive maps, Expert Syst. Appl. 36 (2009) 5221–5229.
[25] G. Kyriakarakos, A.I. Dounis, K.G. Arvanitis, G. Papadakis, A fuzzy cognitive maps–petri nets energy management system for autonomous poly generation micro-grids, Appl. Soft Comput. 12 (2012) 3785–3797.
[26] W. Froelich, W. Pedrycz, Fuzzy cognitive maps in the modeling of granular time series, Knowl. Base Syst. 115 (2017) 110–122.
[27] T. Devisscher, E. Boyd, Y. Malhi, Anticipating future risk in social-ecological systems using fuzzy cognitive mapping: the case of wildfire in the Chiquitania, Bolivia, Ecol. Soc. 21 (4) (2016) 18.